MUT3622: MUSICAL DATA STRUCTURES

Spring 2026

Class: Fr, 9:35am-12:35pm MUB 232
Professor: Dr. Felipe Tovar-Henao (felipe.tovar@ufl.edu), he/him
(you can call me Felipe—pronounced *feh-LEE-peh*)
Office Hours: Th 3-3:50pm, MUB 342

COURSE DESCRIPTION

In this seminar, we will engage with computational methods for the analysis and generation of musical materials and structures to better understand how humans produce and interact with them. Topics covered include music representation and encoding, feature extraction and music information retrieval, corpus studies, analytical and generative machine learning techniques, data sonification, and multimodal human-computer interaction. These techniques will be considered in the context of many different aesthetics, styles, genres, theoretical frameworks, and societal contexts.

Pre-requisites: *none*

COURSE OBJECTIVES

Throughout the course, students will develop skills to quantify aspects of music creation, analysis, and experiential processes using both heuristic and statistical computational techniques. They will explore the history of computing and artificial intelligence, as well as analyze the structure, content, and contexts of existing musical datasets. They will both generate and analyze musical materials using stochastic, rule-based, and machine learning tools. Students will also grapple with questions surrounding the role of automation as it relates to artistic labor, and consider opportunities and adversities afforded to artists by recent technological advancements in machine learning. Ultimately, students will develop basic proficiency with the bell programming language through coding assignments and a final project that assess their ability to work through a development cycle to either create a new system, creative work, or use computational means to analyze human engagement with sound.

REQUIRED MATERIALS

Textbooks

There are no required textbooks, and all readings, datasets, and example code will be posted on the course's Canvas page.

Software

The majority of the course will be taught using a programming language called Bell, using a free and open-source algorithmic audio software called *bellplay~* (https://bellplay.net/). This will also require a dedicated text editor, preferably Visual Studio Code. Depending on your operating system, we may need to do some troubleshooting to ensure that everything runs smoothly. While we'll often be working through examples together, I'm always happy to work one-on-one with you to solve any issues you might

be having. You're also welcome to use other languages (Python, R, MATLAB, C++, Julia, etc.) if you're familiar with them; at the end of the day, I'm much more interested in modes of thinking and ways of solving problems than specific tools that we might use to accomplish our goals, and I'm happy to work with you to find something that fits your workflow/dataset/use cases.
Other pieces of software that you may find useful (and which may be referenced during the semester) include:

- Cycling 74's Max: https://cycling74.com/
- Engraving software of your choice (e.g., Dorico, Sibelius, MuseScore)

Hardware
Access to some sort of computing device will be crucial. If this is not possible, please let me know ASAP and we will try to work with the administration to get you what you need, including but not limited to loaner computers or computer labs. While no additional hardware is necessary outside of a computer, if you would like to purchase a microphone for high-quality recording of audio, we can talk about what options might suit your needs. Your projects may require access to a high-quality audio lab, in which case I will ensure that you have access to studios in the music building.

GRADING

Assignment Breakdown
The course will primarily consist of five algorithmic music puzzles, two midterm projects consisting of small-scale, targeted creative exercises, which are meant to prepare you for the final project, all of which are to be presented in class, and engagement/participation. The final project can take many forms depending on the students' areas of expertise, including by not limited to a composition, an analytical paper, a piece of software, a performance, curriculum design—if you have a different idea, let's talk about how we can make it happen.

Algorithmic puzzles	30%
Midterm project I	15%
Midterm project II	15%
Final Project	40%
Prospectus	5%
Documentation/deliverables	15%
Presentation	10%
Engagement/participation	10%

Assignment Submission
All projects are expected to be completed on time and submitted in their final designated form (this may vary from assignment to assignment) along with any accompanying source materials in a .zip folder in the appropriate folder on Canvas prior to class on the day that they are due. Files should use the naming convention *LastName_AssigmentName.zip* in order to make downloading and grading easier. Feedback will be given within 1 week of on-time assignment submission. While there are no penalties for late

assignments, keep in mind that they may receive abbreviated (or no) feedback from the instructor if they are not submitted on time.

Attendance and Engagement/Participation Policy

Students are expected to attend and be engaged in every class in some way. Because class discussions and in-class workshopping and experimentation will comprise an important part of the course, all members of the class are expected to have completed all relevant assignments and familiarize themselves with all required reference materials. There will be frequent opportunities to share/workshop the outcomes of skill development assignments in class, and so it is important to work on them early and often. In general, the first class period of each week will involve the introduction of new materials in a lecture-style format, whereas the second will be a more experiential, lab-style tutorial. All students and instructors are expected to treat each other with the utmost respect and professionalism, whether physically in the classroom, during office hours, or online. We are all here to learn, so please do not hesitate to ask questions or share your opinions or experiences.

Grading Scale

Letter	%	General Grading Criteria (specific assignment rubrics TBD)
A	93 - 100%	Excellent. Well-prepared and thorough. Shows creativity, diligence, or insight beyond the basic requirements
A-	90 - 92.99%	
B+	87 - 89.99%	Good. Meets basic expectations. Demonstrates a basic understanding of the material, perhaps with minor flaws.
B	83 - 86.99%	
B-	80 - 82.99%	
C+	77 - 79.99%	Fair. Completes the assignment, but demonstrates a less-than-firm grasp of the material; missing elements; multiple technical errors
C	73 - 76.99%	
C-	70 - 72.99%	
D+	67 - 69.99%	Poor. Demonstrates a lack of effort or understanding of the material. Multiple errors, missing elements, or failure to follow assignment instructions
D	63 - 66.99%	
D-	60 - 62.99%	
E	<60%	Fail. Missing, incomplete, plagiarized, or incoherent.

For more information on grading, visit: https://catalog.ufl.edu/UGRD/academic-regulations/grades-grading-policies/

Engagement/Participation Rubric

	Criteria: Present and Prepared	Criteria: Synthesis and Extension
Excellent	Student is present and participatory (either in class, or as the need arises, virtually) and shows evidence of having completed required course materials and assignments (either through in-class discussion or posting on the Canvas discussion board)	Student understands connections between required materials, and considers temporal, technological, and societal contexts in which materials are presented. Comments and questions show that the student is able to build upon insights gained from engagement with materials and connect it to their own experiences, as well as critically consider their own positionality to the material and how it may differ from others. Comments are respectful of others' viewpoints.
Satisfactory	Student is present and participatory (either in class, or as the need arises, virtually), shows evidence of having only superficially or incompletely engaged with required course materials and assignments, (either through in-class discussion or posting on the Canvas discussion board)	Student shows limited understanding of connections between required materials, and/or barely considers temporal, technological, and societal contexts in which materials are presented. Comments and questions are superficial and serve only to regurgitate points raised in the required materials without extending or providing any additional insight or context, or simply provide their experiences without considering positionality to the materials. Comments are respectful of others' viewpoints.
Unsatisfactory	Student is not present and/or does not participate (either in class, or as the need arises, virtually), and shows no engagement with required course materials nor assignment completion	Student makes no effort to connect required materials to each other, nor do they consider the context in which the required materials are presented. Student is inconsiderate of other points of view and/or creates a toxic environment for others in the class.

CAMPUS-WIDE POLICIES AND RESOURCES

- E-learning technical support: Contact the UF Computing Help Desk at 352-392-4357 or via e-mail at helpdesk@ufl.edu.
- Career Connections Center: Reitz Union Suite 1300, 352-392-1601. Career assistance and counseling services.
- Library Support: Various ways to receive assistance with respect to using the libraries or finding resources. Call 866-281-6309 or email ask@ufl.libanswers.com for more information.

- Academic Resources: 1317 Turlington Hall, Call 352-392-2010, or to make a private appointment: 352- 392-6420. Email contact: teaching-center@ufl.edu. General study skills and tutoring.
- Writing Studio: Daytime (9:30am-3:30pm): 2215 Turlington Hall, 352-846-1138 | Evening (5:00pm-7:00pm): 1545 W University Avenue (Library West, Rm. 339). Help brainstorming, formatting, and writing papers.
- Academic Complaints: Office of the Ombuds; Visit the Complaint Portal webpage for more information.
- Enrollment Management Complaints (Registrar, Financial Aid, Admissions): View the Student Complaint Procedure webpage for more information.
- UF Student Success Initiative: Visit https://studentsuccess.ufl.edu/ for resources that support your success as a UF student.
- Public Speaking Lab: (Dial Center, 501 Rolfs Hall). Offering online and in-person help developing, organizing, and practicing oral presentations. Contact email: publicspeakinglab@clas.ufl.edu.

Academic Integrity

UF students are bound by The Honor Pledge which states "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Conduct Code specifies a number of behaviors that are in violation of this code and the possible sanctions. See the UF Conduct Code website for more information. If you have any questions or concerns, please feel free to reach out to me.

Campus Health and Wellness Resources

- UF Whole Gator Resources: Visit https://one.uf.edu/whole-gator/discover for resources that are designed to help you thrive physically, mentally, and emotionally at UF.

Students Requesting Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the Disability Resource Center. See the "Get Started With the DRC" webpage on the Disability Resource Center site. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Evaluations

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online. Students can complete evaluations in three ways:

- The email they receive from GatorEvals
- Their Canvas course menu under GatorEvals
- The central portal at https://my-ufl.bluera.com

Guidance on how to provide constructive feedback is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

Information about university-wide policies and resources can be found at:
https://syllabus.ufl.edu/syllabus-policy/uf-syllabus-policy-links/

WEEKLY CLASS SCHEDULE

NB: this schedule is very likely to change student interest, and group pacing dictates. Thanks in advance for your flexibility!

WEEK 1: 1/16

Syllabus review • Basics of acoustics, psychoacoustics, digital audio • Acoustics: Sound waves, sound pressure, frequency, amplitude, loudness. •Psychoacoustics: Pitch, timbre, spectrum • Digital audio: DACs, sampling rate, bit depth, Nyquist, RMS. • Introduction to Bell and *bellplay~*

Reading due: Bell tutorials, 1 through 10.

WEEK 2: 1/23

Musical data representation: pitch, time, and loudness • Pitch, frequency, MIDI, Piano roll. • Absolute vs. relative time • Linear gain, velocity, and decibels.

Reading due:

- Bell tutorials, 11 through 21.
- *bellplay~* tutorials, 1 through 5.

WEEK 3: 1/30

Rule-based algorithms • Loops • randomization • logic gates • user-defined functions.

Reading due: *bellplay~* tutorials, 6 through 15.
Start assignment:

- Midterm I project presentation
- Algorithmic puzzles I
    - *Regular pulse*
    - *Interval cycle 1*
    - *Regular rhythm*
    - *Repeating arpeggio*
    - *Repeating chord*.

WEEK 4: 2/6

Functions • Common math functions: sin/cos, tanh, atan, sqrt, log2, exp2 • Breakpoint functions, sampling and interpolation • Parametric automation.

Reading due: *bellplay~* tutorials, 16 through 25.

Assignment due: Algorithmic puzzles I
Start assignment: Algorithmic puzzles II

- *Harmonic series 1*
- *Subtractive pattern*
- *Additive pattern*
- *Regular accents*
- *Melodic rotation*

WEEK 5: 2/13

Presentation day
Quantization and MusicXML.

Assignment due: Midterm I project presentation
Start assignment:

- Capstone project proposal

WEEK 6: 2/20

Stochastic and deterministic algorithms • Deterministic: L-systems, Cellular automata, Constraint satisfaction problems • Stochastic: Nth-order Markov chains, Tokenization, Markov feedback.

Assignment due: Algorithmic puzzles II
Start assignment:

- Midterm II project presentation
- Algorithmic puzzles III
    - *Random pitches 1*
    - *Random pitches 2*
    - *Granular texture*
    - *Equal-tempered scales*
    - *Regular durations*

WEEK 7: 2/27

Audio descriptors: Onset detection, Spectral moments (centroid, kurtosis, flatness, spread), MFCC, Pitch, Zero-crossing rate, loudness, Effective duration, Tonal: chords/keys

Assignment due:

- Capstone project proposal
- Algorithmic puzzles III

Start assignment: Algorithmic puzzles IV:

- *Pitch quantization*
- *Regular durations*
- *Melodic sequence*

- *Legato to staccato*
- *Scale triads 1*

WEEK 8: 3/6

Machine learning: Datasets/labelsets • Data scaling: normalization, standardization, robust scaling • multi-dimensional search (KDTree, KNN) • Dimensionality reduction (UMAP, PCA) • Classification and clustering (KMeans)

Assignment due: Algorithmic puzzles IV

WEEK 9: 3/13

Presentation day
Exchanging data between Bell and Python

Assignment due: Midterm II project presentation
Start assignment: Algorithmic puzzles IV:

- *Scalar modes*
- *Interval cycle 2*
- *Harmonic sequence*
- *Slowing pulse*
- *Sine contour 1*

WEEK 10: 3/20

SPRING BREAK—NO CLASS

WEEK 11: 3/27

Corpus studies • Concatenative synthesis; audio mosaicking • SQL databases.
Assignment due: Algorithmic puzzles IV
Start assignment: Algorithmic puzzles V

- *Scale triads 2*
- *Rhythmicon 1*
- *Fractal arpeggio 1*
- *Double harmonic series*
- *Melodic branching*

WEEK 12: 4/3

Deep learning • Neural networks and multi-layer perceptron • Weights • Activations/non-linearities (Sigmoid, ReLU, Tanh) • Loss functions • Training, validation, and testing • Audio source separation with NMF.

Assignment due: Algorithmic puzzles V

WEEK 13: 4/10

Individual meetings

WEEK 14: 4/17

Presentation day
Assignment due: Final Presentation and deliverables.

WEEK 15: 4/24

READING DAYS—NO CLASS